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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04L 7/00 | A2

(11) International Publication Number: WO 98/56136

(43) International Publication Date: 10 December 1998 (10.12.98)

(21) International Application Number: PCT/NO98/00123

(22) International Filing Date: 17 April 1998 (17.04.98)

(30) Priority Data:
972519 3 June 1997 (03.06.97) NO

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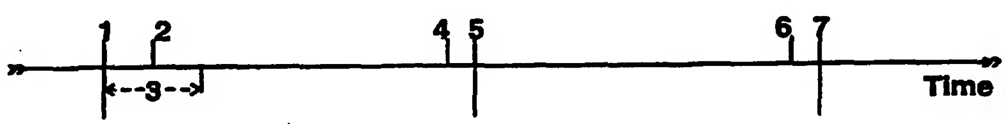
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: METHOD FOR PROVIDING TIME SYNCHRONIZATION IN A NETWORK



Time Sync using proposed method

(57) Abstract

The present invention relates to a method for providing time synchronization in a network, especially in a Local Area Network (LAN), in which network a node comprises a master time distributor designed for broadcasting clock information at regular intervals or on demand, and in order to circumvent the problem of unpredictable delays, and thereby enabling a Very Accurate Time Synchronizati n, the present invention suggests a solution by defining one network event as a "tick", sending from one node such a tick at regular intervals or on demand, one node being defined as the time synchronization master node, and said master node, upon detection of such a tick, sending a message containing the tick arrival time to any node requiring time synchronization.

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METHOD FOR PROVIDING TIME SYNCHRONIZATION IN A NETWORK

Field of the invention

The present invention relates to a method for providing time synchronization in a network, especially in a Local Area Network (LAN), in which network a node comprises a Master Time Distributor designed for broadcasting clock information on demand.

Background of the invention

A common problem on Local Area Networks (LAN) is the concept of Absolute Time. Even if one node is designated a role of Master Time Distributor and responsible for broadcasting clock information on demand, the medium access mechanism of LAN introduces an unpredictable delay to the transfer of time synchronization message. This delay can easily surpass the required precision of the Absolute Time, rendering the whole concept meaningless. In addition, the duration of the time synchronization message and the message handling delays in the receiving Nodes introduce further uncertainties.

Prior art

From US 5 408 506 (Mincher et al.) there is known a distributed time synchronization system and method, wherein some nodes will have their frequency amended in relation to a virtual master clock value.

US 5 440 556 (Edem et al.) relates to a method wherein two circuits on each side of a network line is synchronized to the same reference clock by sending a pulse each 125µs.

US 5 602 922 (Danneels) relates to a system for synchronizing data transmitted from a server to a client, by initializing the clock when the first packet has been received and further comparing the clock times with the packet time. This system may be relevant in connection with video, wherein time distances are relevant.

US 5 544 324 (Edem et al.) relates to a network for transmitting isochronous data by using a frame structure having a variable number of time slots to compensate for timing variants between reference clocks and data rate. An example of an isochronous data sync is a video monitor which can receive a substantially continuous stream of video data for display, and this prior art seeks to transfer such isochronous data in a more appropriate manner.

WO 87/04306 (Ketzler/ETA Systems) relates to an electronic clock control system for digital data computers. The system comprises a master oscillator distributing clock signals to a plurality of circuit cards for regulating the time delay to each circuit card.

WO 93/04544 (Wray/Motorola) relates to a method for adjusting a synchronization signal with a received data signal by using an error signal which defines the difference between said two signals.

<u>Summary of the invention</u>

The object of the present invention is to introduce a procedure of time distribution that will circumvent the problem of unpredictable delays, for thereby enabling a very accurate time synchronization.

This object is based on a defined network event designated a "tick". The requirement for such a tick is only

that it is unique and easily recognizable. Some possible tick candidates are:

- One or more legal network addresses
- One or more legal network group addresses
- A predefined sequence of bits ending in a code violation
- A pulse of predefined length
- A legal packet with enforced code violation in the predefined part

The object of the invention is achieved in connection with a method of the type as stated in the preamble, which according to the invention is characterized by a definition of a "tick", sending such a tick from one node at regular intervals or on demand, one node being defined as the time synchronization master node, and said master node, upon detection of such a tick, sending a message containing the tick arrival time to any node requiring time synchronization.

Further features and advantages of the present invention will appear from the following description of suggested embodiments, as well as from the appending patent claims.

Brief disclosure of the drawing

The invention will now be further described, reference being had to the enclosed drawing.

Fig. 1 is a diagram illustrating the clock distribution sequence using conventional methods.

Fig. 2 is a diagram illustrating the time sync using the methods according to the present invention.

Fig. 3 is a block diagram illustrating an embodiment

wherein the present invention can find its application.

Detailed description of the invention

Firstly, reference is made to Fig. 1 which is diagram illustrating the clock distribution sequence using conventional methods.

In Fig. 1 the numeral references therein mean:

1	Time Sync Master Software reads master clock, prepares time message
2	Time Sync Master Software puts time sync message in transmit queue
3	Maximum allowable difference between local clocks
2-4	Time Sync Master waits for transmit permission
4	Time Sync Master transmits time message and Time Sync Slave receives time message
5	Time Sync Slave Software finished processing time sync message
6	Difference between Time Sync Slave clock and Time Sync Master clock.

The problem with this prior art solution lies in the time interval from 2 to 4 - the period where a clock message is ready for transmission but the node has not yet gained access to the network. The length of this time interval is very hard to predict, as it depends on the bus access mechanism and the current state of the network.

Next reference is made to Fig. 2 which is a diagram illustrating the time sync using the methods according to the present invention.

In Fig. 2 the numeral references therein mean:

1	Time Tick Master Software puts a tick in the transmit queue
2-4	Tick is queued, waiting for transmission

4 Tick is on the medium, Time Tick Master and all Time Tick Slaves receive tick

5 Time Tick Slave Software notes local tick arrival time (T_{1t}), Time Sync Master Software prepares time sync message containing master clock tick arrival time (T_{mt}) and puts it in the transmit queue

5-6 Message containing the absolute time (master clock tick arrival time) is queued in the Time Sync Master Node, waiting for transmission

6 Time Sync Master transmits master clock time message on the medium

7 Time Sync Slaves receive time message (the receiving instant can be different from node to node) and updates local time (T_1) by the time difference between local tick arrival time and master clock time message ($T_1 = T_1 + T_{mt} - T_{1t}$).

If we now look at Fig. 2, the situation is quite different when compared with Fig. 1. The time tick does not contain any clock information. It is intended for all nodes that need absolute time update. The only important thing about the tick is that it should arrive at all such nodes with the same delay every time. When it arrives, every node stores the local time value of its arrival. The Time Sync Master node then prepares a master clock time message containing the time when the tick arrived and transmits it on the network. When this message arrives, all nodes can check the master clock time against their own stored tick arrival time and update their local clock by the difference between the local arrival time and the master clock time.

BASIC PRINCIPLE

The basic principle of the Very Accurate Time Synchronization system is that the time distribution procedure is changed from one-step to two-step.

A synchronization event (tick) is defined on the LAN. The restrictions on such a tick is only that it is unique and easily recognizable. Some possible tick candidates are:

- One or more legal network addresses
- One or more legal network group addresses
- A predefined sequence of bits ending in a code violation
- A pulse of predefined length
- A legal packet with enforced code violation in the predefined part

A synchronization event is detected in a specified position in the tick.

The two-step time distribution procedure is as follows:

1. One node of the LAN is responsible for generating synchronization events at regular intervals or on demand. The detection of a synchronization event by LAN nodes is a time-critical element of the procedure.

2. One node of the LAN is assigned the role of the Master Time Distributor. Whenever this node detects a synchronization event on the LAN, it records the time when the event was detected and broadcasts a message containing the recorded time to all nodes that require time synchronization. The transfer of this message is not time-critical.

This approach eliminates the impact of the LAN medium access delay, but one still has to cope with the delay of processing synchronization events. This can be solved if every node that requires time synchronization fulfils some basic requirements.

REQUIREMENTS ON LAN NODES

Fig. 3 shows a block diagram of a Local Area Network node. Such a node must satisfy four requirements:

1. A raw data stream from the LAN interface 2 must be available.

2. A Time Sync Detector 3 that can detect a specified synchronization event in the raw data stream, must be added.

3. The node 1 must be able to maintain local time between time synchronization messages.

4. The node CPU or the local clock handling hardware must be able to react on the signal from Time Sync Detector 3.

VERY ACCURATE TIME SYNCHRONIZATION PROCEDURE

If all nodes requiring time synchronization fulfil the requirements presented in the last paragraph, the procedure of very accurate time synchronization is as follows:

1. When a synchronization event is detected, the Time Sync Detector 3 notifies the CPU or the local clock handling hardware.

2. The local time for that event is recorded.

3. If the node is the time synchronization master, the recorded time is transmitted in a message to other nodes that require time synchronization.

4. All other nodes wait for the time distribution message from the master node. When this message

arrives, the local clock is adjusted of a difference between the received time and the recorded time of the synchronization event occurrence.

Using this procedure the time synchronization uncertainly is reduced to four very small components:

- The transmission delay on the network medium. For almost all Local Area Networks this delay is below 10μs.
- The resolution of the local clock hardware. This is usually well below 1μs.
- The difference in the detection of synchronization event. This can be equal to the resolution of the local clock or better.
- The difference in the reaction time on the synchronization event detection. Even if the reaction time can be on the level of 40μs or more, the difference in the reaction time will usually be below 1μs.

In this way the Very Accurate Time Synchronization procedure approaches the theoretical limit (light speed) of time distribution over the LAN medium.

Patent claims

1. Method for providing time synchronization in a network, especially in a Local Area Network (LAN), in which network a node comprises a master time distributor designed for broadcasting clock information at regular intervals or on demand,
characterized by defining one specific network event as a "tick",
- sending from one node a packet containing such ticks at regular intervals or on demand,
- one node being defined as the time synchronization master node, and
- said master node, upon detection of such a tick, sending a message containing the tick arrival time to any node requiring time synchronization.

2. Method as claimed in claim 1,
characterized in that said tick is defined at the moment when the last bit of a particular set of network addresses is detected.

3. Method as claimed in claim 1 or 2,
characterized in that a local node is adapted to receive a raw data stream from said network, especial a Local Area Network (LAN) through an appropriate interface.

4. Method as claimed in any of the preceding claims,
characterized in that said local node is adapted to communicate with a Time Synchronization Detector for detecting a tick from the network interface raw data.

5. Method as claimed in any of the preceding claims,
characterized in that said local node is adapted to keep time between synchronization messages.

6. Method as claimed in any of the preceding claims, characterized in that any local node(s) is(are) adapted to receive a Time Distribution Message plus the amount of time that has passed since the tick arrived.

FIG. 1

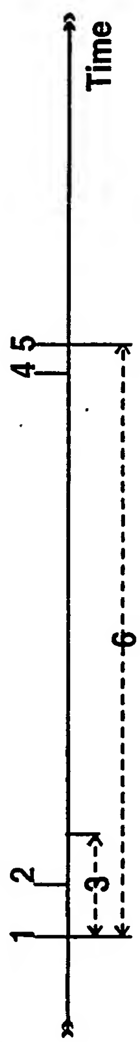

Figure 1. Conventional time sync message transmission

FIG. 2

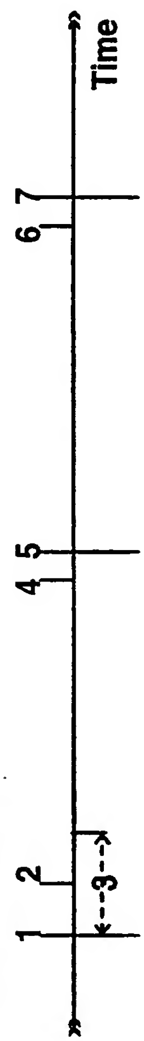

Figure 2. Time Sync using proposed method

Fig.3